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Army Standard Platform Object

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13. ABSTRACT (Maximum 200 words)
Object-oriented programming offers the potential for increased code reuse, maintainability, and ease of developing entity-level simulations. Because of these benefits, the use of object-oriented technologies will increase over time. In order to prevent duplication of effort and the development of incompatible models, the Deputy Undersecretary of the Army for Operations Research (DUSA-OR) directed the development of an Army object management initiative to provide a foundation for Army object development. This report documents the standard Platform Object that defines the minimum set of objects and object methods needed for the development of Platform Objects in models and simulation.

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ACRONYM LIST.

AMSAA	Army Materiel Systems Analysis Activity
AMSMPWG	Army M&S Management Program Working Group
ASTARS	Army Standards Repository System
CAA	Concepts Analysis Agency
CASTFOREM	Combined Arms Task Force Evaluation Model
CSS	Combat Service Support
DUSA(OR)	Deputy Undersecretary of the Army for Operations Research
JWARS	Joint Warfare Simulation
ModSAF	Modular Semi-Automated Forces
NSC	National Simulation Center
OMSC	Object Management Standards Category
OMWG	Object Management Working Group
OOP	Object Oriented Programming
SAMSO	Standard Army Modeling and Simulation Object
SNAP	Standards Nomination and Approval Process
STRICOM	Simulation, Training, and Instrumentation Command
TRAC-FLVN	TRADOC Analysis Center Ft. Leavenworth
TRAC-MTRY	TRADOC Analysis Center - Monterey
TRAC-WSMR	TRADOC Analysis Center -White Sands Missile Range
TRADOC	U.S. Army Training and Doctrine Command
WARSIM	Warfighter Simulation

ARMY STANDARD PLATFORM OBJECT

1. INTRODUCTION

This report documents the development of the Army standard Platform Object. For this effort, the definition of a platform encompasses any item that can be treated as an entity. Examples of this definition include vehicles (tanks, trucks, helicopters, etc.), individual humans, and anything else that can be treated as an individual item (i.e., air defense missiles or remotely emplaced sensor packages, etc.). These types of entities are typically used in simulations where there is an interest in representing the behavior, characteristics or performance of the individual element versus representing the aggregate or composite behavior, characteristics or performance of a collection of these entities.

2. BACKGROUND

Many of the current Army and Joint model development efforts have embraced the use of Object Oriented Programming (OOP) for their model development efforts. As a result, there has been a proliferation of competing object models. In 1QFY97, the Deputy Undersecretary of the Army for Operations Research (DUSA(OR)) formed an Object Management Working Group (OMWG) to propose a policy addressing the need for standards associated with Army M&S objects. The proposed policy developed by the OMWG recommended that the Army focus on a high-level object class structure independent of any specific simulation environment. This would allow M&S developers to tailor the high-level object standards to their specific applications through lower-level classes/ instantiation that extend the standards to a specific M&S requirement. The overall impact in the development of standard abstract objects will be to organize future M&S along a common object structure to support interoperability, object reuse, and community understanding of the M&S. The proposed policy was briefed by the OMWG to the DUSA(OR) and was accepted in principle. AMSO subsequently formed the Object Management Standards Category (OMSC) in April 1997 to initiate the proposed policy. The OMSC mission is to:

- develop abstract objects for Army M&S functions,
- identify the minimum set of object methods/public data associated with the object function, and
- link the object methods to standard algorithms/data sources obtained from the other AMSO standard categories.

The OMSC is comprised of M&S practitioners to include those from the following agencies:

- Army Materiel Systems Analysis Activity (AMSAA) -- serves as the OMSC Coordinator;
- Concepts Analysis Agency (CAA);
- National Simulation Center (NSC);
- TRADOC Analysis Center - Ft. Leavenworth (TRAC-FLVN);
- TRAC- Monterey (TRAC-MTRY),
- TRAC-White Sands Missile Range (TRAC-WSMR); and
- Simulation, Training, and Instrumentation Command (STRICOM).

3. APPROACH

During the initial stages of developing a policy on objects, AMSO funded the U.S. Army Training and Doctrine Command (TRADOC) Analysis Center in Monterey, California (TRAC-MTRY) to perform the 'Standard Army Modeling and Simulation Object (SAMSO) Study'[1]. The study proposed an approach to object development based on object composition. The OMSC reviewed the SAMSO general approach to object development and adopted it for use in developing Army Standard objects. A paper describing the component approach to model development is provided in Appendix A.

As a part of the SAMSO study, the study proponents developed sample platform and unit objects. The OMSC selected the sample platform object design for use as the initial prototype for developing a standard Army Platform Object. To explore the capability of the Platform Object to address expected M&S platform implementations, the OMSC conducted a number of M&S test applications. The simulations chosen for the test applications were the AMSAA Groundwars simulation and the TRAC-WSMR CASTFOREM/ COMBAT XXI simulation. The results of these test applications were used to refine the Platform Object. Additionally, to gain a broader perspective on the application of the draft Platform Object to other M&S domains, an overview of the revised draft Platform Object was provided to the Army M&S Management Program Working Group (AMSMP WG) and the Army M&S Standard Categories for review. Comments were collected and reviewed to determine if any changes to the Platform Object were needed to address differing M&S requirements. Based on these reviews, an updated version of the draft Platform Object was developed and submitted to the Standards Nomination and Approval Process (SNAP) and the Army Standards Repository System (ASTARS).

[1] Buss, Arnold, and Leroy Jackson (September 1997), "Standard Army Modeling and Simulation Objects: Interim Report", US Army TRADOC Analysis Center – Monterey.

4. PLATFORM OBJECT INITIAL DESIGN

An output of the SAMSO Study was a draft Platform Object and Unit Object. (The Unit Object will be described in a separate report). Members of the SAMSO study team reviewed documentation from a number of existing and developing Army models. The models reviewed included: Janus; Joint Warfare Simulation (JWARS); Modular Semi-Automated Forces (ModSAF); and Warfighter Simulation (WARSIM) 2000. Based on this research, the study team identified a set of components that were common to the platforms represented in the models.[2] This Initial Platform Design (IPD) is shown in Figure 1.

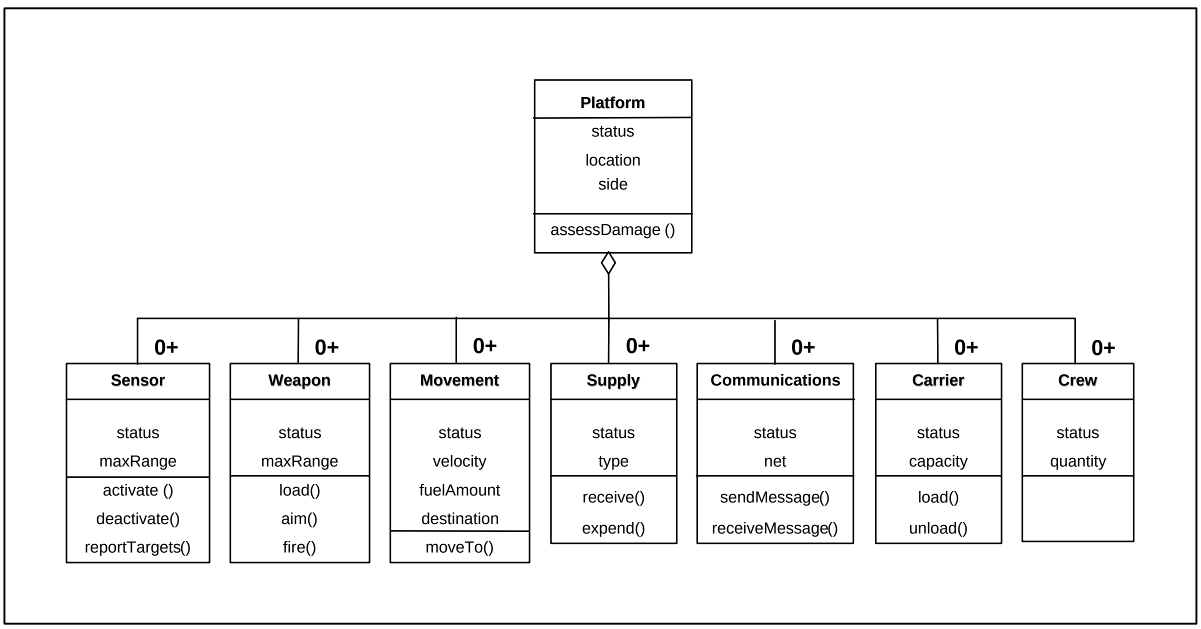

Figure 1. Initial Platform Object Design.

[2] Dudgeon, Douglas E. (September 1997) "Development of Standard Platform-Level Army Object Model, MS Thesis. Department of Operations Research, Naval Postgraduate School.

5. PLATFORM OBJECT TEST APPLICATION

The basic philosophy behind the development of any standard object is its use as a building block in the development of model-specific objects. In order to determine the utility of the proposed platform standard object, the IPD was used to develop sample platform objects for a number of existing entity level simulations. The models addressed by the IPD were the AMSAA Groundwars simulation, TRAC-WSMR CASTFOREM/COMBAT XXI simulation, and the NSC WARSIM 2000 simulation.

5.1 Groundwars Platform Object Implementation.

The first model used to test the IPD was the Groundwars model developed and used at the Army Materiel Systems Analysis Activity (AMSAA). Groundwars is a few-on-few, direct-fire ground combat model that simulates a simplified scheme of maneuver using statistical terrain. The model was designed to investigate the impact of changes to a weapon system's capabilities on the outcome of a small battle. Examples of the types of system capabilities that Groundwars can examine are: changes in the lethality of a munition; changes in the target acquisition capabilities of a sensor; and changes in the delivery accuracy of a munition.

On 11-12 October 1997, Major Jack Jackson of TRAC-MTRY, Don Hodge (AMSAA), and Gary Comstock (AMSAA), met to apply the IPD to the development of Groundwars-type ground vehicle objects. The resulting design contained six components, with five of the components based on the IPD. Figures 2-6 show the composition of each of these components compared to the appropriate IPD component. Figure 7 shows the composition of the new component identified as needed for a Groundwars type of model.

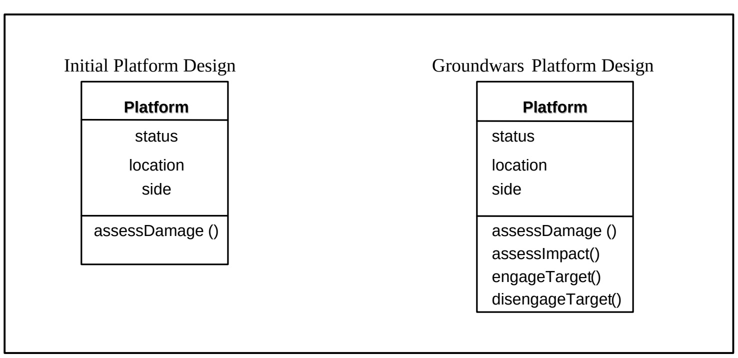

Figure 2. Groundwars Platform Class Design.

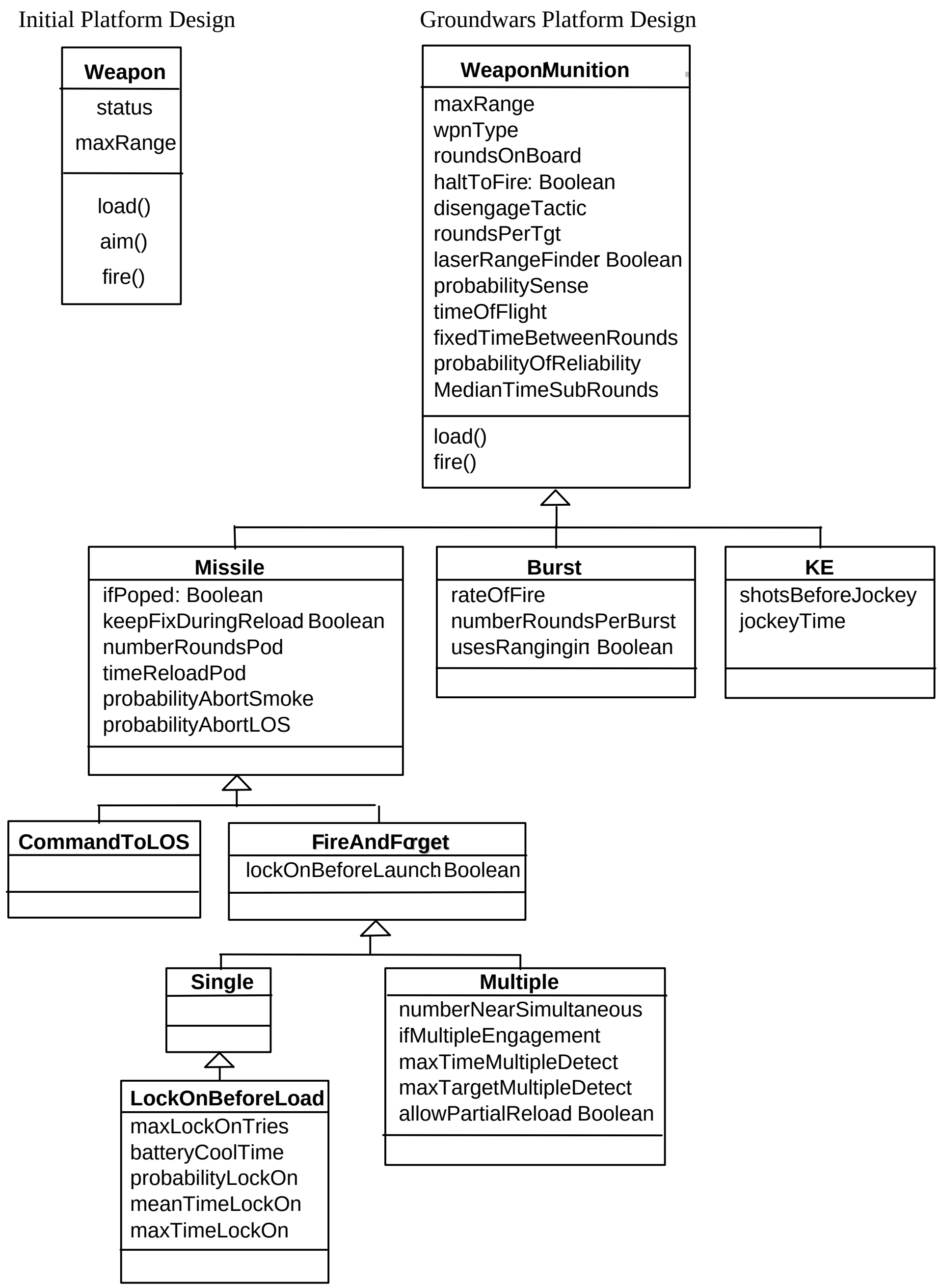

Figure 3. Groundwars Weapon Component Design.

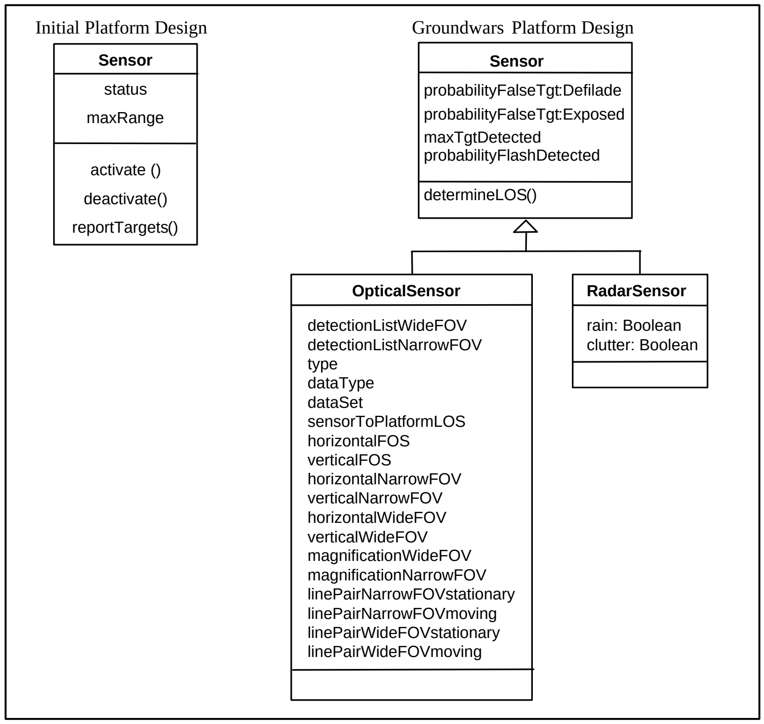

Figure 4. Groundwars Sensor Component Design.

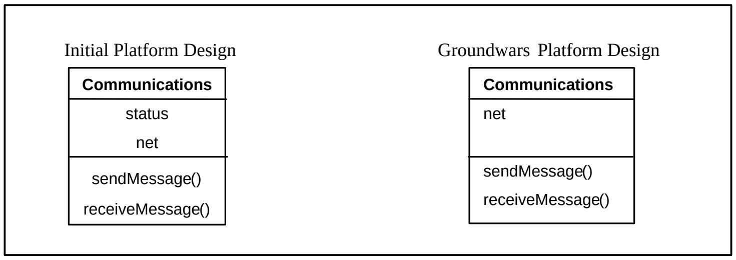

Figure 5. Groundwars Communications Component Design.

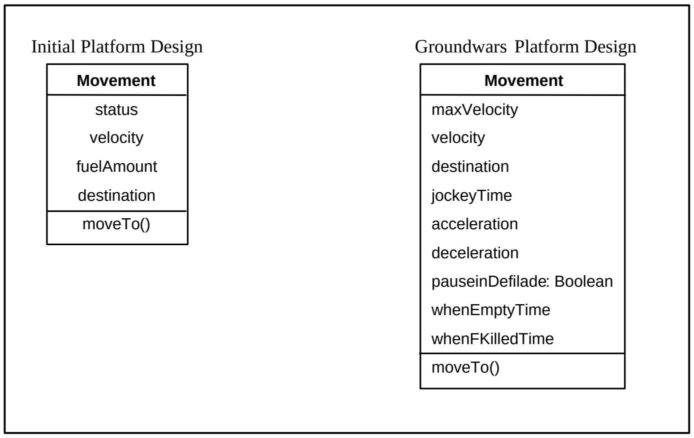

Figure 6. Groundwars Movement Component Design.

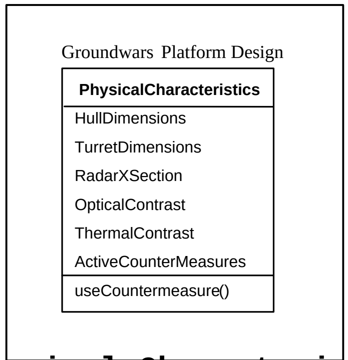

Figure 7. Groundwars Physical Characteristics Component Design.

Overall, the IPD standard components were found to be adaptable and adequate to meet functional requirements found in developing ground vehicle objects that could be used in a Groundwars-type model. Most of the additional details added to the IPD components for this application, as shown in the form of attribute data, were model specific, i.e., the additions were required to support the specific functions of the Groundwars model.

While many of the Groundwars-specific additions to the IPD fit within the general philosophy proposed by the OMSC, there were two areas that caused some concern. The first was the requirement to provide a description of the physical characteristics of the ground vehicles used in Groundwars. These platform physical characteristics are used by the target acquisition sensors to determine target detection and acquisition. While there were sensor objects in the IPD, there were no components in the IPD structure to provide target signature information.

The second area of concern dealt with the model cognitive decision-making processes. In almost all simulations there are certain decisions and/or choices that are required to allow the simulation to execute according to design. For combat simulations, an example of a required decision would be the rules of engagement used by a firing unit. These types of decisions revolve around deciding, for a given target class at a given range, which of the available munitions to fire. The IPD structure, as used during these sample object development efforts, did not contain a component which would logically host these types of decision processes.

5.2 CASTFOREM/COMBAT XXI

The second model used to test the IPD was the Combined Arms Task Force Evaluation Model (CASTFOREM) developed by the TRADOC Analysis Center located at the White Sands Missile Range in New Mexico (TRAC-WSMR). CASTFOREM is a combined-arms brigade and below combat simulation. The model uses approved tactics and doctrine exercised on digital representations of real terrain to assess impact of improved weapon systems on battle outcome. At this time TRAC-WSMR is in the process of developing the follow-on model to CASTFOREM called COMBAT XXI.

On 15-16 October 1997, Major Jackson and Don Hodge met with Donna Vargas, Carol Denney, Chad Mullis, Dave Hoffman, Joe Agular, and Doug Mackey[3] to apply the IPD to the development of platform objects for use in a CASTFOREM/COMBAT XXI-type model. The resulting design was composed of 17 components, with eight of these components coming from the IPD. Figures 8-15 show the composition of the components that came from the IPD. Figure 16 portrays the additional components identified during this effort. Figure 17 depicts other objects, independent of the platform object, that were identified as necessary for a Combat XXI type of model.

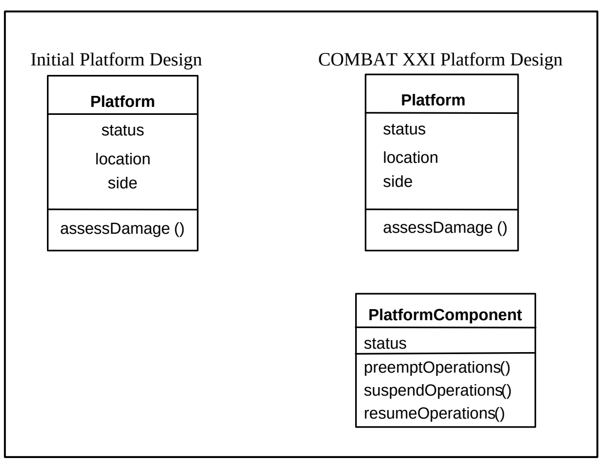

Figure 8. Combat XXI Platform Class Design.

[3] The individuals listed here are members of the original CASTFOREM development team as well as members of the COMBAT XXI development team.

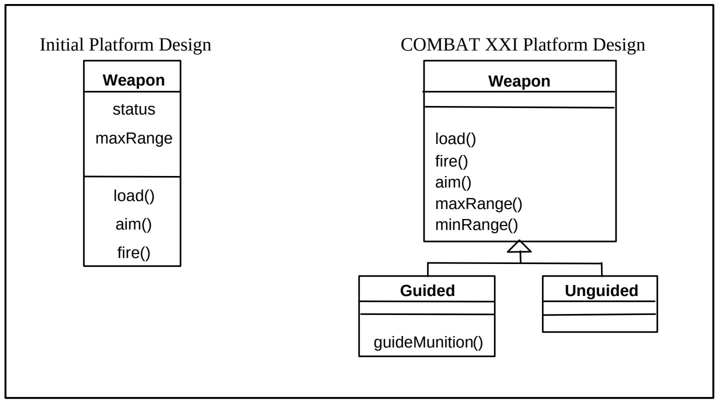

Figure 9. Combat XXI Weapon Component Design.

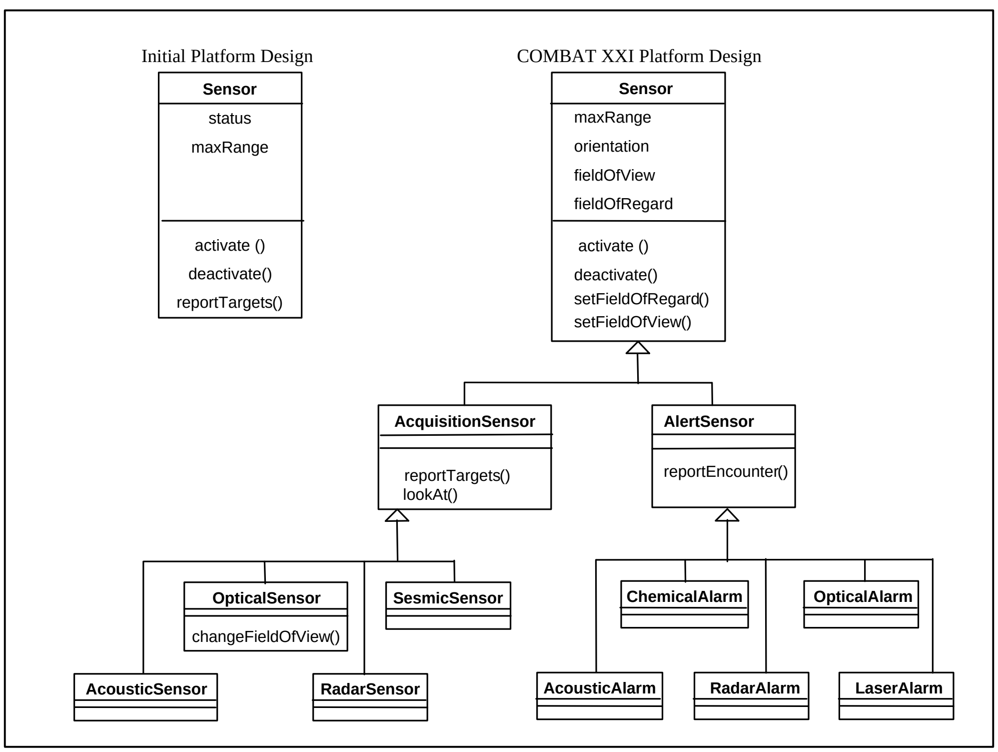

Figure 10. Combat XXI Sensor Component Design.

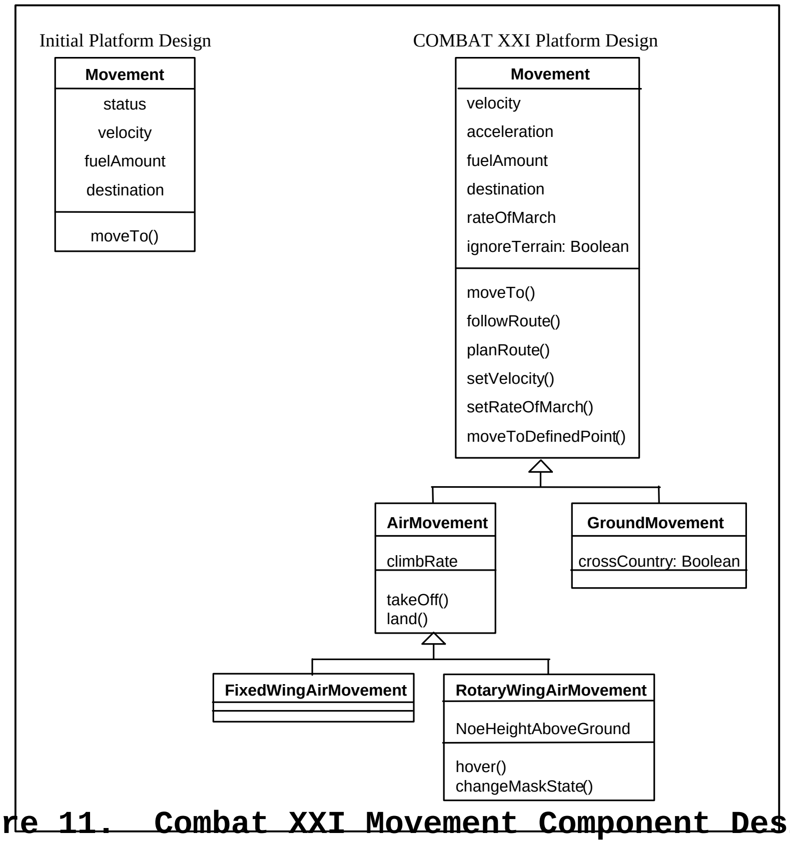

Figure 11. Combat XXI Movement Component Design.

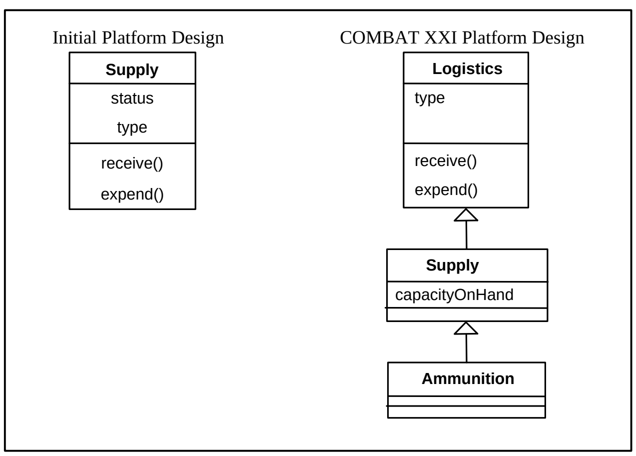

Figure 12. Combat XXI Logistics Component Design.

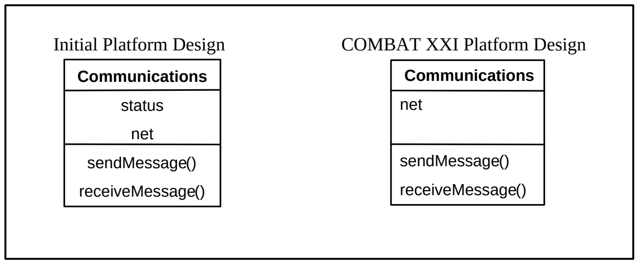

Figure 13. Combat XXI Communications Component Design.

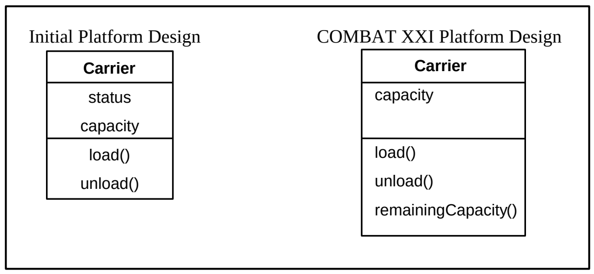

Figure 14. Combat XXI Carrier Component Design.

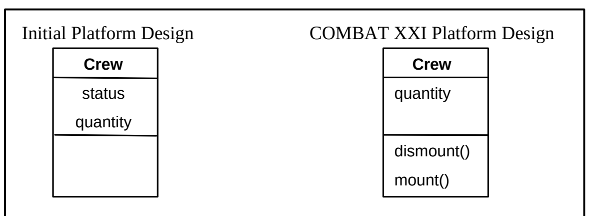

Figure 15. Combat XXI Crew Component Design.

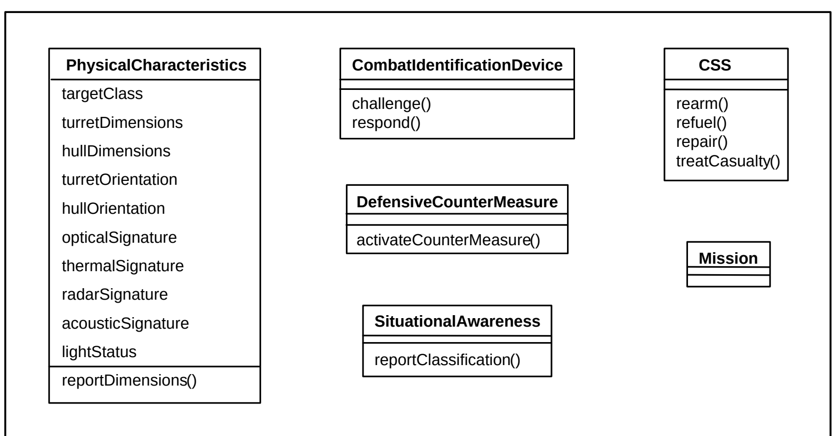

Figure 16. Combat XXI Additional Platform Components.

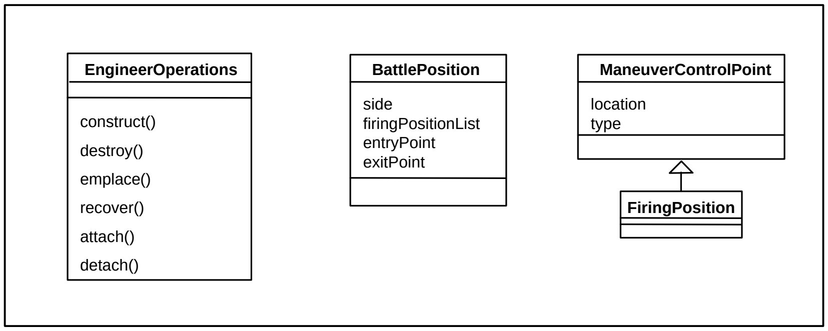

Figure 17. Combat XXI Additional Model Components.

As with the Groundwars experience, the IPD standard components were found to be adaptable and adequate to meet the functional requirements found in developing platform objects for a CASTFOREM/COMBAT XXI-type model. Most of the additional details added to the IPD components for this application were model specific. The two areas of concern identified in the earlier Groundwars effort (i.e., physical descriptions and decision-making processes) were also experienced in this effort.

6. PLATFORM OBJECT DESIGN REVIEW

After the test application using the Groundwars and CASTFOREM/COMBAT XXI simulations, the OMSC met to agree on required modifications to the draft Platform Object. In addition, the modified draft design for the Platform Object was provided to a number of groups throughout the Army for review and comment. These groups included the Army Model and Simulation Management Program Working Group (AMSWG) and all of the other Army Model and Simulation Standards Category Committees. The results of the review included specific written input from the WARSIM simulation developers and the logistics community. The results of the OMSC review along with a summary of the other comments are provided in this section.

6.1 OMSC Review

On 28-29 October 1997, the OMSC committee met to review the results of the two test object design efforts. The members present for this meeting were Brad Bradley (Chairman), Don Hodge (AMSAA), John Shepherd (CAA), Sean MacKinnon (NSC), Mike Hannon (TRAC-FLVN), Major Jack Jackson (TRAC-MTRY), Carol Denny and Donna Vargas (TRAC-WSMR), and Ben Paz (STRICOM). After the review of the two design efforts, the OMSC modified the IPD in the following ways:

1. Added a new component (i.e., PlatformFrame) to provide a description of the physical characteristics of each platform,

2. Added a new component (i.e., PlatformComponent) as a super component to provide for common functions found in each of the identified functional components. These common functions were status and type,

3. Changed the name of the Supply component to Logistics and identified sub-components in order to add a place for maintenance functions,

4. Changed the attribute data found in the IPD to methods that would return the attribute data, and

5. Added a number of new methods to the existing components.

The interim design is shown in Figure 18.

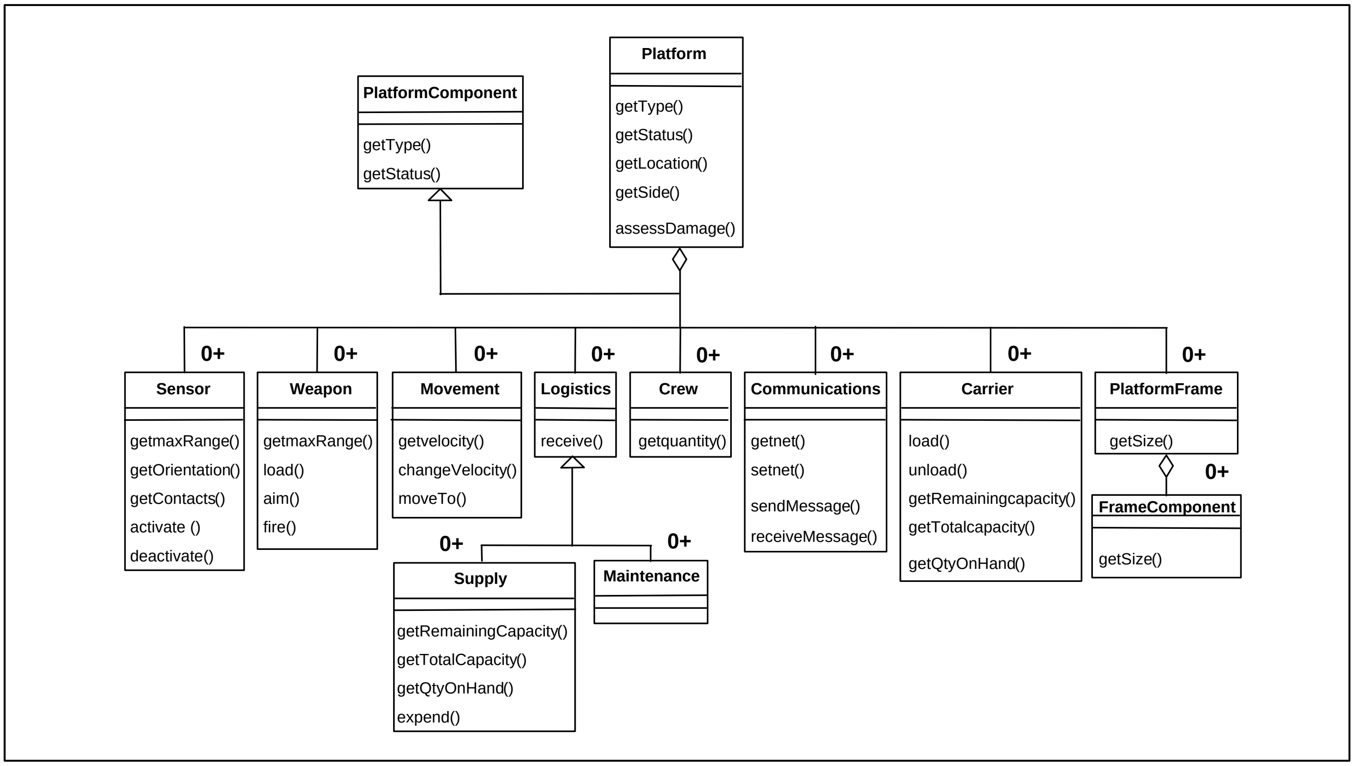

Figure 18. OMSC Interim Platform Object Design.

6.2 WARSIM 2000

Representatives from the National Simulation Center (Sean MacKinnon and Kevin Gippon) conducted a comparison between the interim Platform Object and Unit Object and similar objects being developed for the WARSIM 2000 program (Appendix B). Figure 19 shows the WARSIM 2000 platform object structure.

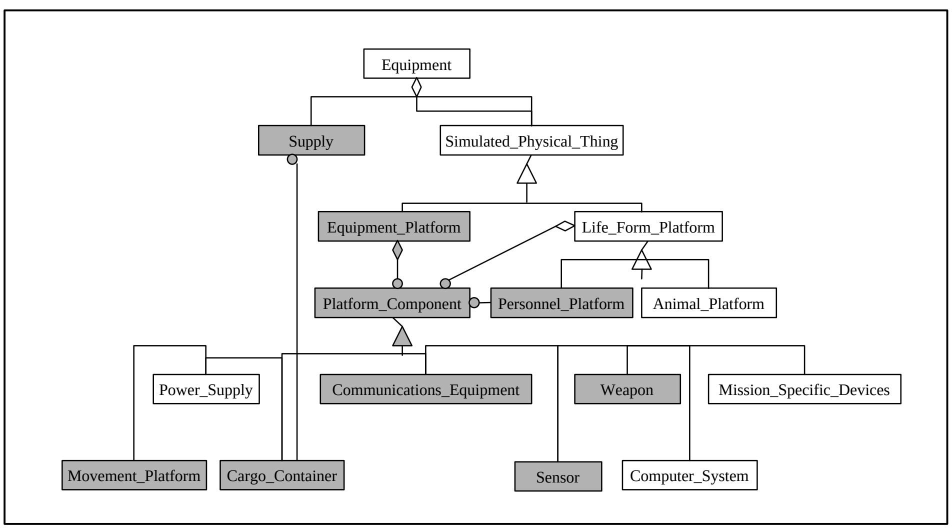

Figure 19. WARSIM 2000 Platform Object Design.

At first glance the two designs appear to be different. This apparent difference is attributable to the different assumptions made in developing each design. The WARSIM 2000 object model was designed to mirror the Operational Requirements Document developed for the WARSIM 2000 program. The interim standard Platform Object is oriented around physical processes and functions. Table 1 provides a comparison between the functions performed by the components of each design. From this table we can see that the functions provided by each design are comparable. There are some differences related to the location of some functions and to the nomenclature used to describe some of the functions. Based on this review, no changes were recommended to the interim Platform Object.

Table 1. Comparison of OMSC and WARSIM 2000 Functional Components.

3. OMSC	4. WARSIM
5.	6.
7. Platform	**8. Equipment_Platform**
9. Platform Component	10. Platform Component
11. Logistics 12. Maintenance	13. Attributes and Methods
14. Supply	15. Supply
16. Carrier	17. Cargo-Container
18. Communications	19. Communications-Equipment
20. Crew	21. Personnel-Platform
22. Movement 23. PlatformFrame 24. FrameComponent	25. Movement-Platform
26. Sensor	27. Sensor
28. Weapon	29. Weapon

6.3 Combat Service Support (CSS)

As a result of discussions between the OMSC and Logistics SC members at the May 1998 Army M&S Standards Workshop, the OMSC was provided a list of the minimum CSS requirements that are desired to be represented in combat simulations. The list is comprised of the following sets:

ARM

- Conduct ammo transfer operations
- Account for direct and indirect fire ammo by type

FUEL

- Conduct fuel transfer operations, including Refuel On Move
- Provide visibility of fuel quantities on hand

MAN & MEDICAL

- Conduct medical evacuation and treatment operations
- Generate types of combat and Disease and Non Battle Injury (DNBI) casualties

FIX

- Conduct maintenance operations
- Conduct evacuation and recovery operations
- Generate combat and reliability failures

After reviewing these requirements and the interim platform design, the OMSC addressed each as follows:

a. The Supply Sub-Component of the Logistics Component of the interim Platform Object addresses the following CSS elements:

ARM - Account for direct and indirect fire ammo by type
FUEL - Provide visibility of fuel quantities on hand

b. Addition of the method "transfer()" to the Supply Sub-Component of the interim Platform Object will address the following CSS elements:

ARM - Conduct ammo transfer operations
FUEL - Conduct fuel transfer operations, including Refuel On Move

c. Add the method "conduct_maintenance" to the Maintenance Sub-Component of the Logistics Component of the interim Platform Object to address the following CSS elements:

MAN & MEDICAL - Conduct medical treatment operations
FIX - Conduct maintenance operations

d. The Carrier Component of the interim Platform Object addresses the following CSS elements:

MAN & MEDICAL - Conduct medical evacuation operations
FIX - Conduct evacuation and recovery operations

e. Generation of combat casualties and combat damage should be addressed by the appropriate methodologies in the assessDamage() method of the interim Platform Object.

7. FINAL PLATFORM OBJECT DESIGN AND DEFINATIONS

7.1 Final Platform Object Design

Figure 20 shows the final design for the Platform Object. This design is based on the OMSC review documented in this report and input provided by the M&S community. This design was nominated in the Standards Nomination and Approval Process for placement into the Army Standard Repository System.

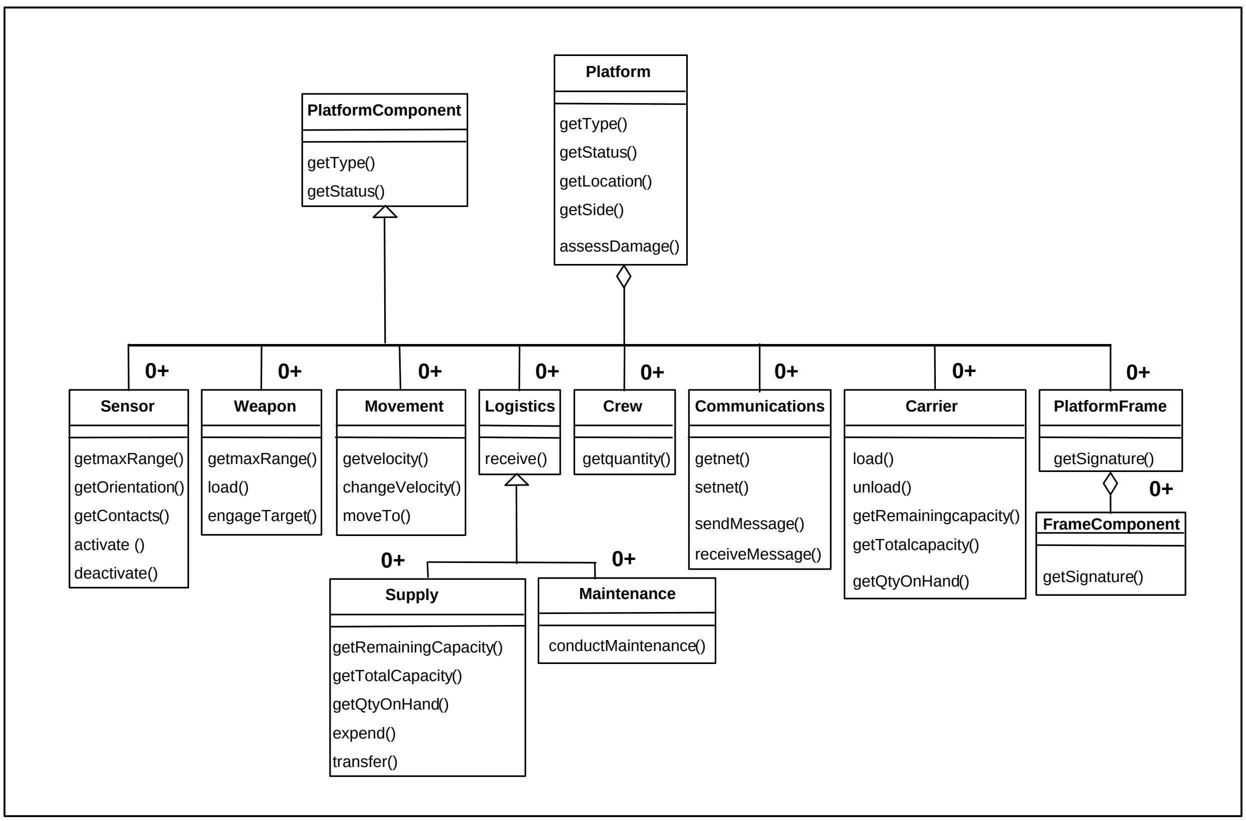

Figure 20. OMSC Final Platform Object Design.

7.2 Platform Object Class and Component Definitions

A detailed description for each of the components and methods contained in the platform object standard definition is provided below.

Class Platform. A platform can be any entity of interest in the model. Examples include vehicles of all types, individuals/ persons, individual systems (i.e., radar systems), a missile, etc.

Public Methods:

- getType(): Returns the type designation for the platform.
- getStatus(): Returns the platform status. The status is typically an enumeration of the standard kill categories (M, F, MF, or K). It can simply be either alive/dead (1/0). It can be derived from the component status.
- getLocation(): Returns the current platform location.
- getSide(): Returns the faction or coalition for the platform. There is no implied enmity between sides.
- assessDamage(): Used to instruct the platform to calculate the damage caused by another object.

Class PlatformComponent. A platform is partitioned into logical components so that the modeler can compose a platform from the components. Components may be extended through inheritance. All of the components listed below will inherit the following two methods from this class.

Public Methods:

- getType(): Returns the component type designation.
- getStatus(): Returns the status of a component; status is typically either functional or nonfunctional (1/0).

Class Sensor. This element models the component of a platform that detects other platforms. Examples of sensors include crew vision, infrared sights and radar.

Public Methods:

- getMaxRange(): Returns the maximum range of the sensor (may be used to reduce the area to be searched).
- getOrientation(): Returns the direction of sensor orientation.
- getContacts(): Used to query the targets currently visible to the sensor component.
- activate(): Used to place the sensor in an active mode.
- deactivate(): Used to place the sensor in an active mode.

Class Weapon. Used to describe the weapon systems on the platform.

Public Methods:

getMaxRange(): Return the max range for specified munition.

load(): Used to load a munition (this creates the weapon/munition pair).

engageTarget(): Used to initiate the weapon-firing event.

Class PlatformFrame. The component contains the physical description of the platform. This may be a detailed model, but typically is data required by sensors to acquire/detect the platform. Examples of the physical data are the visual signature, thermal signature, acoustic signature and cross sectional area. Platform orientation and other descriptions also belong here.

Public Methods:

getSignature(): Returns the signature of the target appropriate for the type of sensor being used.

Class FrameComponent. FrameComponents can be used to describe individual parts of the PlatformFrame. Providing separate descriptions for both the hull and turret of a tank is one use of this component.

Public Methods:

getSignature(): Returns the signature of the target component appropriate for the type of sensor being used.

Class Movement. This class describes the movement capabilities of a platform.

Public Methods:

getVelocity(): Returns the current velocity (direction of movement and rate) of the platform.

changeVelocity(): Used to request a change in velocity.

moveTo (): Used to order the platform to move directly to a location.

Class Logistics. This component is intended to capture or represent the internal logistics capability and/or requirements of the platform.

Public Methods:

receive(): Used to increment the quantity of this logistic component.

Class Supply. This component is intended to represent individual classes of supply used by the platform. Ammunition could be one example of this class.

Public Methods:

- getRemainingCapacity(): Returns the remaining capacity for this supply component.
- getTotalCapacity(): Returns the total capacity for this supply component.
- getQuantityOnHand(): Returns the quantity of this supply that is on hand.
- expend(): Used to expend a quantity of the supply component.
- transfer(): Used to transfer a quantity of an on hand supply component to another platform.

Class Maintenance. This component is intended to represent maintenance actions/requirements of the platform. Since the platform object can be used to describe both systems and people the action can also be used to describe the medical treatment of injuries.

Public Methods:

- conduct_maintenance(): Used to perform maintenance action on platform.

Class Crew. This component is intended to represent individual crew activities for a platform.

Public Methods:

- getQuantity(): Returns the number of crewmembers on the platform.

Class Communications. Provides the platform the ability to send and receive messages.

Public Methods:

- getNet(): Returns the collection of objects capable of exchanging messages.
- getNet(): Used to add the platform to the collection of objects capable of exchanging messages.
- sendMessage(): Used to send a message on the net.
- receiveMessage(): Used to receive a message from the net.

Class Carrier. This component allows the platform to carry other objects. Examples of items that could be carried include other platforms, individuals (i.e., non-crew), and supplies.

Public Methods:

- load(): Used to load objects on the carrier.
- unload(): Used to unload objects carried.

getRemainingCapacity(): Return the number of additional objects of this type that can be loaded.
getTotalCapacity(): Return the total number of objects of this type that can be carried.
getQtyOnHand(): Returns the number of this type on hand.

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APPENDIX A

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A Component Approach to Object Model Standards for Simulation

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Summary. Object models are an important feature of the United States Department of Defense (DoD) High Level Architecture (HLA) and the Defense Modeling and Simulation Office (DMSO) Conceptual Model of the Mission Space (CMMS). Currently, all major DoD simulations under development use object-oriented methodologies. The major benefits of object-oriented programming include software reuse, improved maintainability, interoperability, and rapid prototyping. A set of standard objects is needed to establish consistency among future Army models and simulations. This paper describes a component approach proposed for object model standards development.

1. INTRODUCTION

This paper describes a component approach for object-oriented modeling and design which has been adopted for standards development in the U.S. Army modeling and simulation community. This design approach directly supports the goals for developing object modeling standards by fostering model reuse and improving model interoperability.

2. BACKGROUND

In May 1997, the U.S. Army Training and Doctrine Command (TRADOC) Analysis Center (TRAC) in Monterey, California (TRAC—Monterey) began a study sponsored by the Army Modeling and Simulation Office (AMSO) to support standards development for Army modeling and simulation objects. [1] The study team was led by a military analyst at TRAC—Monterey and included a professor and two graduate students from the Operations Research Department of the Naval Postgraduate School. The study advisory group included senior analysts from the major Army analytical agencies. The team examined selected models from existing and future simulations under development in order to provide examples and insights to support object standards development. The team also developed an approach to object model standards development, drafted sample standards for platforms (entities) and units, and drafted sample guidelines for the use of standard objects. The study team determined that object model standards would focus on high-level abstract classes containing a minimal, essential set of class methods. Rather than specify standard attributes for classes, *get* and *set* methods would signify the data content of standard objects. An important aspect of the study team recommendations was the component approach to object model standards.

3. APPROACHES TO REUSE

The two main approaches to reuse in object oriented designs are class inheritance and object composition. [2&3] Each approach has distinct advantages and disadvantages.

3.1 Inheritance

Inheritance allows subclasses to extend and specialize a parent class by adding data and methods, and by replacing the method implementation of the parent class with a new implementation. Inheritance is straightforward since it is directly supported by object oriented languages. General classes are placed higher in the inheritance hierarchy and more specialized objects lower, so several subclasses may reuse the parent class. Inheritance, however, breaks encapsulation by exposing the parent class implementation to its subclasses. Implementation changes in the parent class often necessitate changes in subclasses. Issues of multiple inheritance and the requirement for compile-time binding further dilute the value of inheritance for reuse. Inheritance promotes implementation dependencies. Despite some minor disadvantages, inheritance is an extremely important feature in object oriented systems. Inheritance of abstract classes provides common protocols or interfaces in an object-oriented design. This technique ameliorates some of the pitfalls in the use of inheritance.

3.2 Object Composition

Object composition is the construction of a class using instances of other classes as components. Because component classes are accessed through their interface (public methods), encapsulation is not broken and there are significantly fewer implementation dependencies. Object composition is, however, more difficult. It requires that component classes have well defined interfaces that promote reuse. In addition, objects must respect these interfaces since no implementation details are exposed. Finally, object composition proliferates numerous small component classes since each component class must focus on relatively few tasks. This often requires many interrelationships among the component classes that would normally be encapsulated in one larger class.

3.3 The Component Approach to Standards

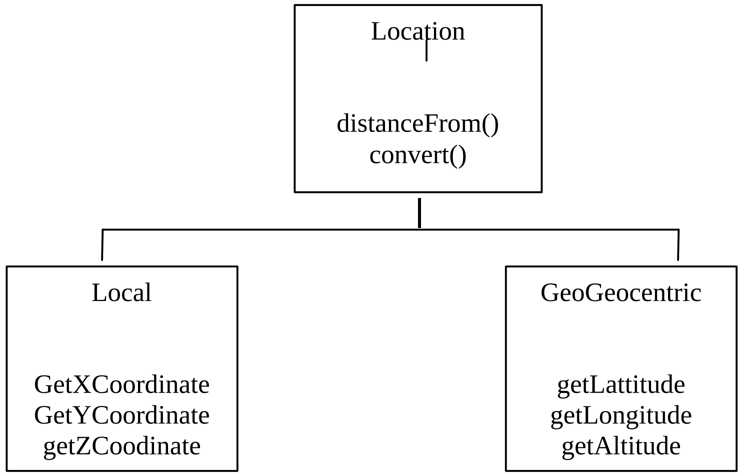
The component approach to standards favors object composition over class inheritance, but exploits the advantages of both approaches. With the component approach, classes of interest are constructed by selecting and implementing abstract component classes. Component classes are implemented and possibly extended through inheritance. The principle advantage of the component approach to standards over alternative approaches is it focuses on the development of standard interfaces rather than the construction of a single monolithic class hierarchy. If a single class interface supports several different implementation schemes, then the goal of “plug and play” software components is achieved. For example, if the same method signature (set of parameters required to invoke the method) supports several attrition schemes (Lanchester, Bonder-Ferrel etc.) then it is possible to substitute one attrition algorithm for another without making other changes in the simulation.

4. STANDARD M&S OBJECTS

This section provides examples of standard modeling and simulation (M&S) objects developed using the component approach and discusses the problem of determining the appropriate level of detail for standards using the component approach.

4.1 *Location* Class Example

The notion of location is fundamental to most military simulations. There are numerous coordinate systems used in simulation; each is appropriate for some simulations and not suitable for others. A common, abstract location object can foster interoperability among simulations that use different coordinate schemes. In this example (see next page), the *Location* class abstracts the concept of location by providing a method to calculate the distance between locations and to convert to an unspecified standard location scheme. The *Location* class has two standard subclasses, *Local* and *Geocentric*, which illustrate the two main competing coordinate schemes. Each provides location through *get* methods. [4] The *Location* class is powerful and flexible. Suppose one has a simulation that uses a network of arcs and nodes. The distance between nodes is stored in a table and the distance from a node along an arc is calculated based on the fraction of the arc traversed at the time a distance is requested. The simulation developer conforms to the standard by simply subclassing the *Location* class and implementing its methods.



Location Class Hierarchy

4.2 *PlatformComponent* Example

Entity level simulations of combat generally have a notion of platform or entity upon which most militarily significant actors from individual combatants to tanks to aircraft are based. While the details vary significantly among various simulations, there are common aspects of all platforms in almost all entity level simulations. The standard platform components are *Location*, *Communications*, *Movement*, *Sensor*, *Weapon*, *Carrier*, *Crew*, *PlatformFrame* and *Logistics* (with *Supply* and *Maintenance* subclasses). These components are subclasses of the *PlatformComponent* class that provides *getType* and *getStatus* methods to all components. (The interested reader can refer to [4,5&9] for the details of the platform components.) A simulation developer composes platforms in an entity-level simulation using zero or more of each of components as appropriate. Implementation details are left to the developer, but each component provides a standard interface into a significant aspect of the entity as illustrated by the *Location* class described above. The standard platform components are flexible. The simulation developer uses only the components required in the simulation. If, for example, the crew is not modeled, then that component is omitted. There is no restriction on the number or type of weapons, sensors or communications systems on the platform.

4.3 Levels of Detail for Standards

The component approach does not solve the problem of determining the appropriate level of detail for standard classes, but it provides a suitable context for debate on this issue. The study team used several general rules to determine if a method belonged in a standard class. The primary rule was that the method be essential to support a function found in almost all simulations where the component would be found. The study team made a conscious effort to err on the side of proposing minimal standards to avoid creating a large burden for the simulation developer. The shared vision was of abstract components as the basis for standards. In the approach described, the abstract components are sufficient to assemble a platform that represents the abstract tank. Further refinement would be required to produce a generic tank and still more refinement to produce a detailed model of an actual tank. Each level is a possible standard, but the fraction of simulations which might support the more detailed standards is rather small.

5. CONCLUSION

The U.S. Army modeling and simulation community is reviewing standard component models for platform and unit objects which evolved from the study. The Object Management Standards Coordinating Committee has proposed a general framework for object model development and is actively developing standard component models for a variety of other significant objects found in ground combat simulations. The component approach to object modeling promotes reuse of models and improves model interoperability. It focuses on the development of a standard object interface which consists of the minimum, essential set of abstract class methods in a component.

6. ACKNOWLEDEMENTS

This work was sponsored by the Deputy Undersecretary of the Army for Operations Research through the auspices of the U.S. Army Modeling and Simulation Office. I am particularly indebted to Professor Arnold Buss of the Naval Postgraduate School for his keen insights and tremendous contributions to the study.

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Major Leroy A. Jackson is an Army officer with over 20 years of enlisted and commissioned service. He graduated with a BA in Mathematics from Cameron University in 1990 and with an MS in Operations Research from the Naval Postgraduate School in 1995. He is currently an operations research analyst at the U.S. Army Training and Doctrine Command (TRADOC) Analysis Center (TRAC) Research Activities in Monterey, California and continues graduate studies in operations research at the Naval Postgraduate School.

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APPENDIX B

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WARSIM 2000 Crosswalk with the OMSC Object Model Standard

26 Feb 98

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Background

The OOA approach chosen by the WARSIM IDT closely follows the Rumbaugh OMT methodology. The WARSIM IDT extracted nouns and noun phrases from the Operation Requirements Document (ORD) to identify the object classes required within WARSIM and to establish traceability back to user requirements. A simplified model of this process is illustrated in Figure 1. This approach drove the IDT away from the development of a functionally oriented class structure, therefore, a lot of differences have been noted between the two unit models. As an example, the WARSIM unit model does not contain functional classes such as Attrition, Geometry, Logistics, etc. Because of the fundamentally different OOA approaches applied, these functions are represented within the WARSIM models by attributes and methods. We have attempted to create abridged representations of both the WARSIM Equipment and Unit models so that a visual comparison could easily be made. The following sections highlight some of the differences between the WARSIM and OMSC object models.

Platform Model Crosswalk

There appears to be about an 85 percent or better correspondence between the two object models. The WARSIM Equipment Model contains all the components of the OMSC standard except for the Logistics and Maintenance classes. The WARSIM Equipment Model represents logistics and maintenance as attributes and methods. In addition, the WARSIM Equipment Model contains a Simulated Physical Thing class. The WARSIM Team developed this abstract class as a way of capturing the operations and attributes for any simulated entity on the battlefield that has a state and is subject to detection and attrition. Figure 2 and Table 1 are provided for visual comparison between the two models.

Unit Model Crosswalk

As previously stated, the WARSIM team avoided developing class structures based on functionality. This fundamental difference in the OOA approach made the comparative crosswalk difficult. Figure 3 and Table 2 show the correspondence between the OMSC and WARSIM unit models. About 20 percent or less of the items are the same for each unit model. However, all OMSC unit model items are represented within the WARSIM unit model. The most notable differences are that the Equipment model takes care of attrition and the WARSIM C2 processes shown in Figures 4 and 5. Table 3 provides some definitions for the WARSIM classes. The below sections provide specific comments on the OMSC unit model.

Unit Class:

There is some concern over the use of the term “sides”. This may inadvertently force us into the traditional red Vs blue way of thinking. Conversely, in the WARSIM model an attribute of alliance has been created to more accurately depict the real-world (we for alliances based upon common interests and goals). It appears that posture is a term used for simulation convenience for abstracting mission and Unit State. There is nothing in doctrine corresponding to posture. A mission is a large complex data structure. If mission is expected to be an enumerated value in this model then objects are needed to describe at least a rudimentary plan. An “executeMission()” is needed. In WARSIM attrition will not be determined by Unit, rather the results of combat at the platform level (WARSIM will keep track of platform location and movement as part of a formation) will be reported to Unit as damage occurs. An assessment process in Unit will maintain unit composition and status. So the “determineAttrition” method would not be used. Also, WARSIM uses heading versus MvmtDirection.

SystemGroup Class:

Within the WARSIM simulation we may have unit instances without Systems groups. Although units are composed of systems, WARSIM will model equipment separately from their units to provide additional composibility. This is different approach from the OMSC unit model.

Geometry Class:

WARSIM uses the term formation rather than shape. Within the WARSIM object model, formation is an attribute of the Unit class. Again for composibility reasons and based on the OOA approach used, WARSIM does not have a functional class like geometry. Within WARSIM, such a class might bring about a specific implementation versus being a more general representation.

C2 Class:

WARSIM has a very detailed outline for the C2 process as illustrated in Figure 4 which can be traced to the doctrinal military decision making process. The OMSC Unit model contains only doC2.

Attrition Class:

WARSIM will use attrition methods which will be executed by equipment interactions and will be maintained as part of the Equipment model.

Logistics Class:

This is handled by AEQ_Equipment.

Communications Class:

This is handled through SMCO.

Conclusion

Although there is a good amount of similarity between the OMSC Platform model and the WARSIM Equipment model, the approaches used to develop unit object models are fundamentally different. This is not to say that one approach is better than the other, rather, the WARSIM focus on satisfying training requirement and the JSIMS Enterprise influence have driven the development of WARSIM object models.

Recommendation

The WARSIM IDT has expressed interest in getting involved in the OMSC process to develop Army M&S community standards. Recommend that the OMSC contact the WARSIM IDT and possibly schedule a future meeting in Orlando. This would provide an opportunity for the WARSIM IDT to share insight into their overall development process and the thought behind their current object models.

Requirements Development Flow

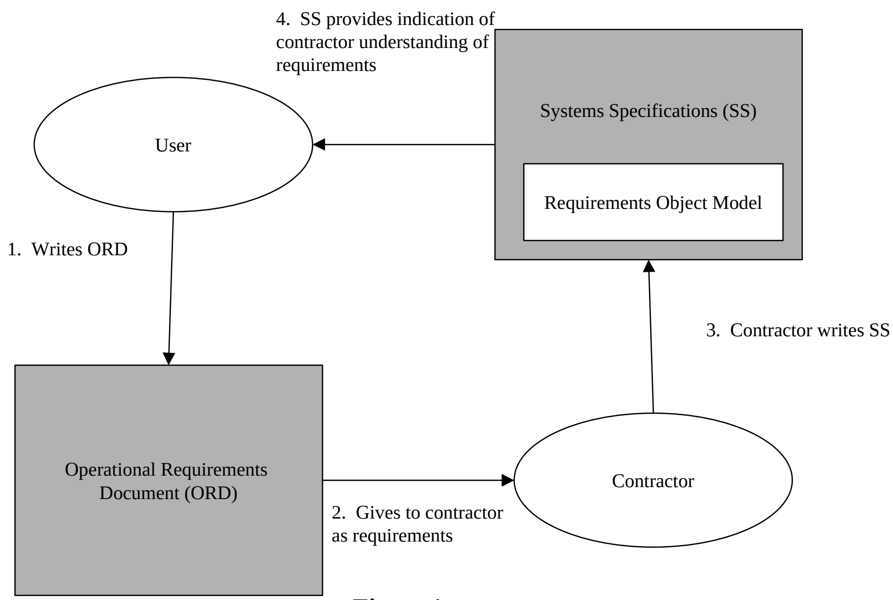

Figure 1

OMSC Platform Model

WARSIM Platform Model

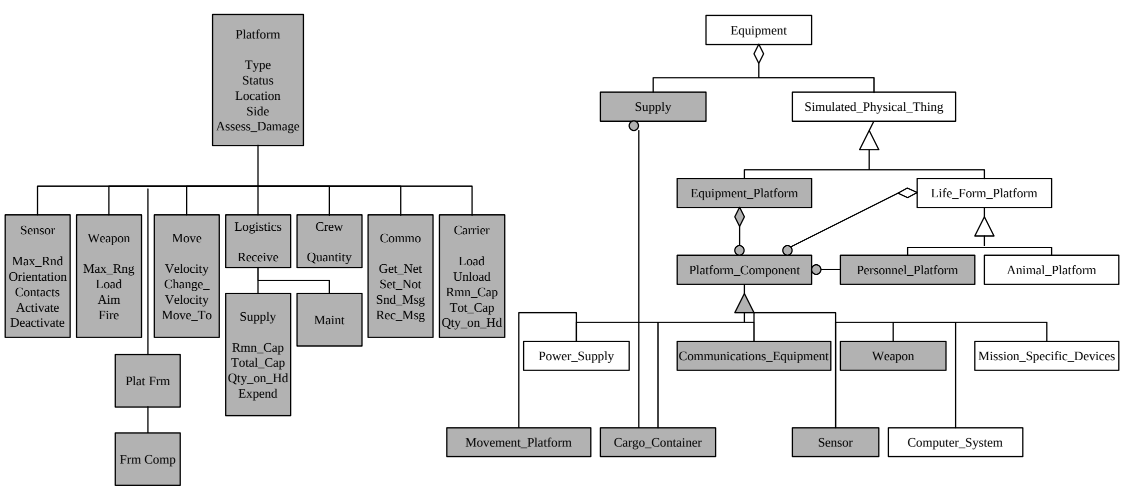

Figure 2

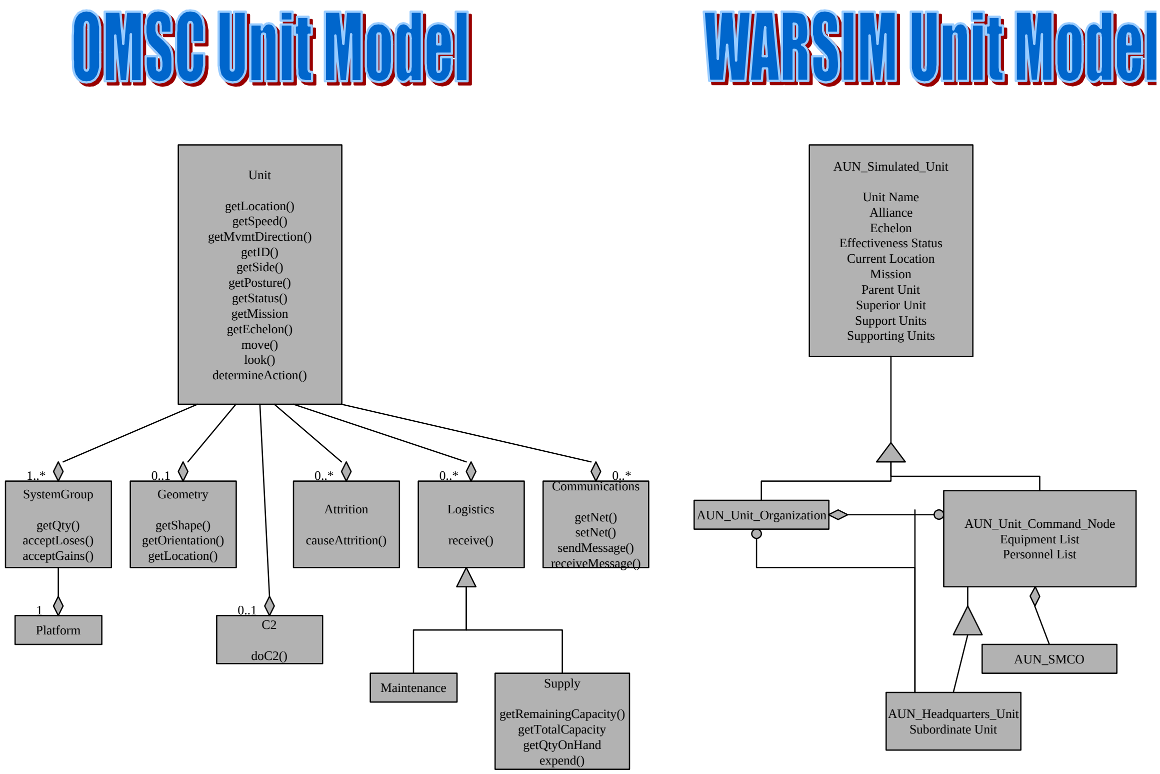

Figure 3

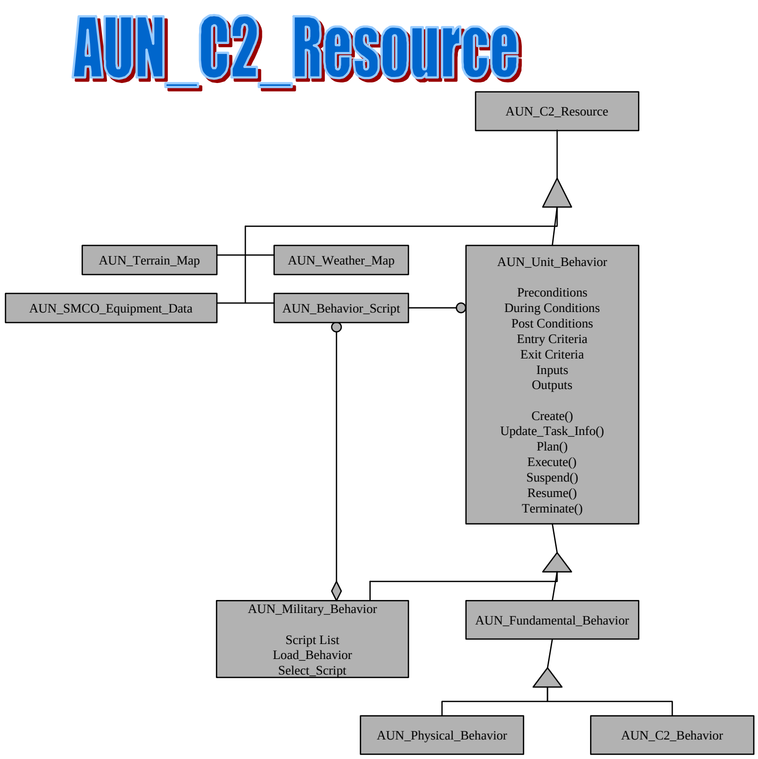

Figure 4

AUN_Unit

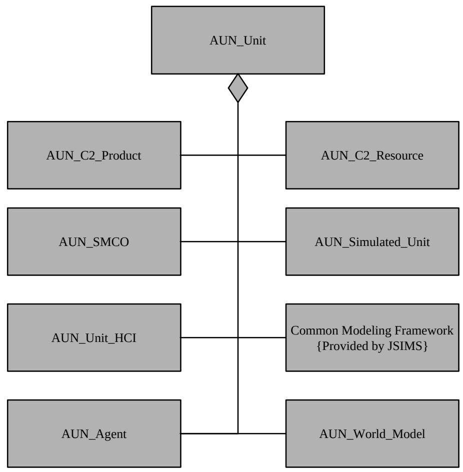

Figure 5

Comparison of Platform Models – Table 1	
OMSC	WARSIM
Platform	Equipment_Platform
Platform Component	Platform-Component
Logistics Maintenance	Attributes and Methods
Supply	Supply
Carrier	Cargo-Container
Communications	Communications-Equipment
Crew	Personnel-Platform
Movement PlatformFrame FrameComponent	Movement-Platform
Sensor	Sensor
Weapon	Weapon

Comparison of Unit Models – Table 2	
OMSC	WARSIM
Unit	AUN_Simulated_Unit
GetID()	Unit Name
GetSide()	Alliance
GetEchelon()	Echelon
GetStatus()	Effectiveness Status
GetLocation()	Current Location
GetMission()	Mission
GetSpeed() GetMvmtDirection() GetPosture() DetermineAction()	AUN_C2_Behavior (see Figure 4 for details about organization)
Move()	AUN_Physical_Behavior (see Figure 4 for details about organization)
Datalook()	AUN_SMCO_Equipment_Data passes info to AUN_SMCO

Comparison of Unit Models – Table 2 Cont.	
OMSC	WARSIM
SystemGroup GetQty() AcceptLoses() AcceptGains()	AUN_Unit_Command_Node
Platform	AUN_SMCO
Geometry GetShape() GetOrientation() GetLocation()	AUN_C2_Behavior
C2 DoC2()	AUN_C2_Resource
Attrition CauseAttrition()	AEQ_Equipment sends info to AUN_SMCO_Equipment_Data
Logistics Receive()	AEQ_Equipment
Maintenance	AEQ_Equipment
Supply GetRemainingCapacity() GetTotalCapacity() GetQtyOnHand() Expend()	AEQ_Equipment
Communications GetNet() SetNet() SendMessage() ReceiveMessage()	AUN_SMCO

Definitions - Table 3	
AEQ_Equipment	Subsystem that maintains equipment and send information about equipment to AUN_SMCO_Equipment_Data.
AUN_C2_Behavior	C2 fundamental behaviors are the atomic cognitive behaviors. The military decision making process is implemented through a combination of C2 fundamental behaviors.
AUN_Physical_Behavior	Physical fundamental behaviors have their effects in the equipment csci. All physical action of a unit occurs through physical fundamental behaviors.
AUN_Unit_Command_Node	This class represents a group of equipment and personnel at the lowest modeled echelon level that functions, and is controlled, as an atomic element. This means that the unit will behave as a single entity. For example, all of the tanks and their crews of a tank platoon will move together in a single formation.
AUN_Simulated_Unit	Unit class
AUN_SMCO	Unit command nodes have a SMCO. A unit command node's SMCO represents the minds of all the unit command node's personnel. Unit Command Node's have a specialization class called Headquarters Unit. A headquarters unit's SMCO not only directs the actions of its own physical objects, but also commands and monitors subordinate headquarters units via orders and reports.
AUN_SMCO_Equipment_Data	Contains information about the equipment.
Simulated_Physical_Thing	This object class contains the operations and attributes for any simulated entity that has a state and is subject to detection and attrition.

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